MDRU
MINERAL DEPOSIT RESEARCH UNIT

THE UNIVERSITY OF BRITISH COLUMBIA

SEG Canada Foundation

Characterizing Zircon Porphyry Copper Fertility Characteristics in the Evolving Laramide arc, east-central Arizona

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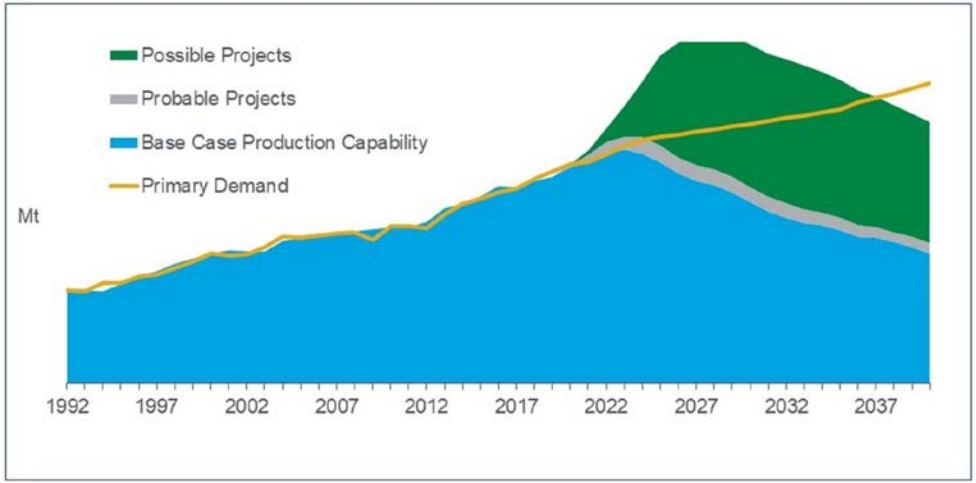
MDRU – Mineral Deposit Research Unit, Earth, Ocean and Atmospheric Sciences, University of British Columbia

Demand for Copper



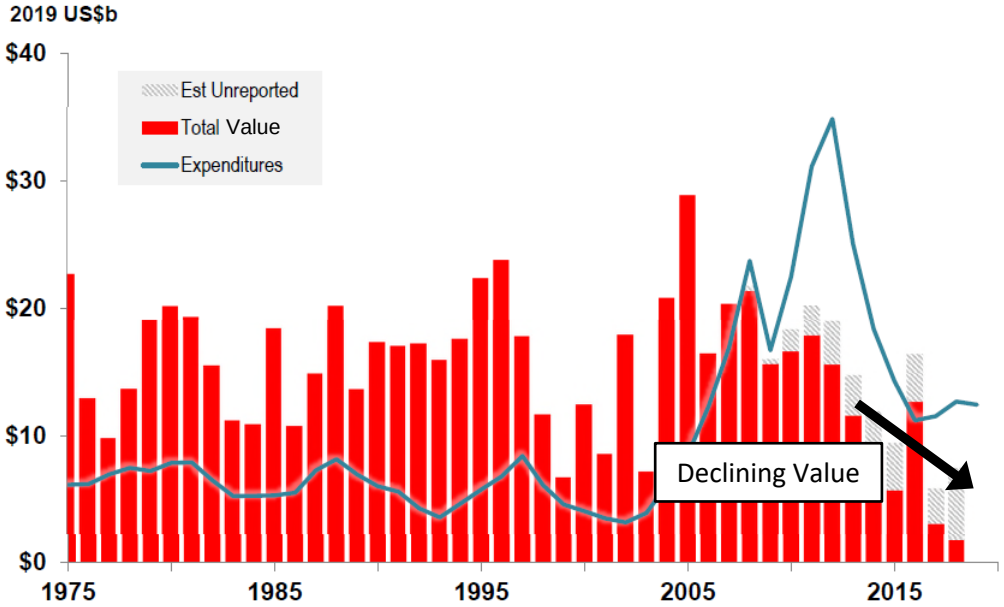
Wood Mackenzie (2019)

Copper usage has **increased by 3.4%** annually since the 1900's.

Reliance on **renewable energy** and **EV's** will continue to drive global demand.

New discoveries are needed to meet **Cu demand**.

Cost and Value in Exploration: 1975-2018

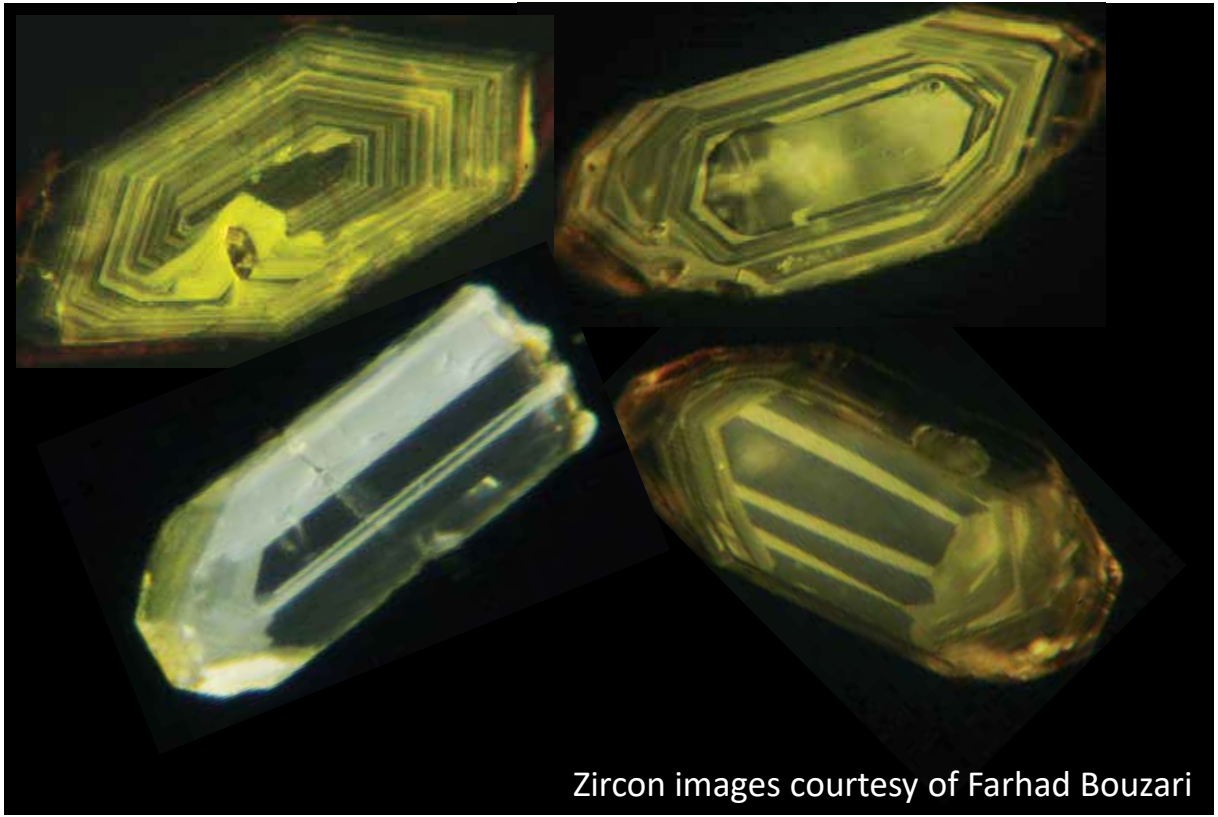


Schodde (2019)

Conventional Exploration Methods are **ineffective**

New Tools are needed to **identify deposits** and asses their **economic potential**

Porphyry Magma Fertility – Trace Elements in Zircon (TEZ)



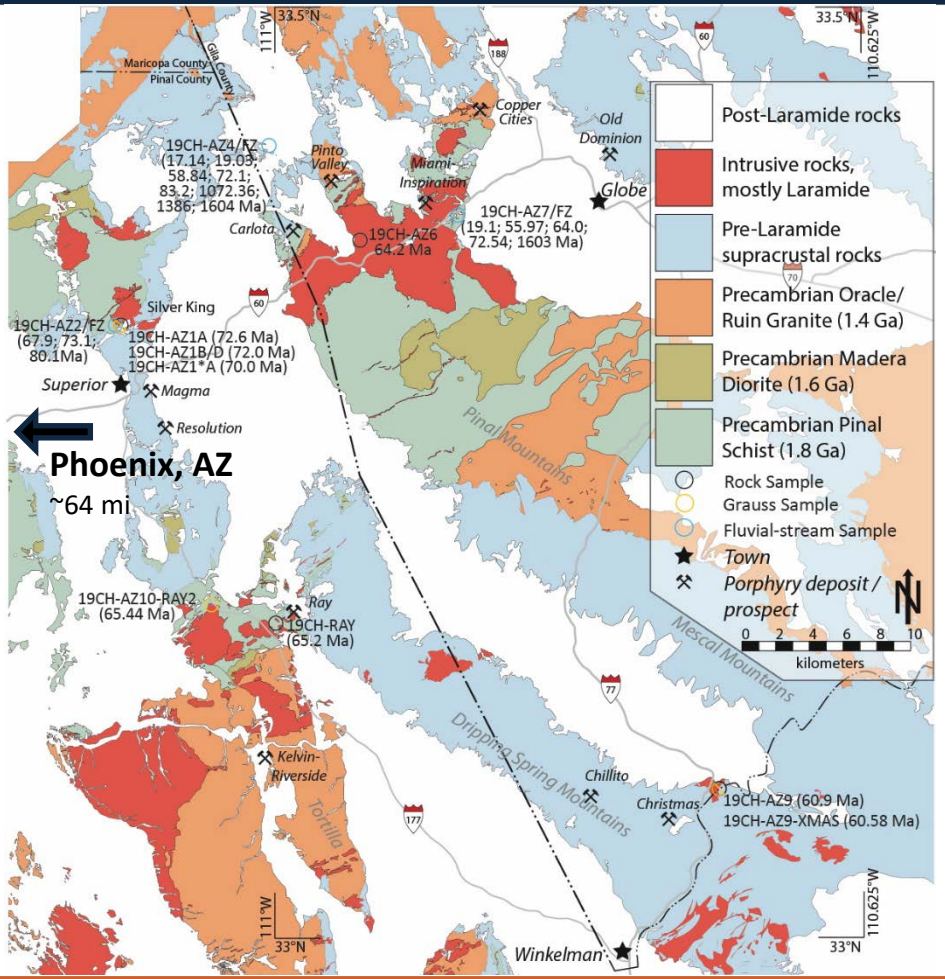
Regional Geology

Variable Proterozoic Continental Basement

Laramide Arc

- Arc magmatism **migrated eastward**
- **Composite** intrusive complexes
- **Dioritic** to **granitic** intrusions
- Magma Composition **evolved** to be more **silicic**
- **Mineralizing** intrusions during **final stages** of magmatism

Cenozoic Extension



Geology after Seedorff et al. (2019)

Previous Geochronology

Superior District (ca. 75.2 to 63.5 Ma)

- Silver King ca. 75.2 to 72 Ma
- Magma Vein ca. 73.1 to 65.1 Ma
- Resolution ca. 70.4 to 63.5 Ma
- Superior East ca. 65 to 63.5 Ma

Globe-Miami District (ca. 69.8 to 59.9 Ma)

- Schultze Pluton (ca. 69.8 to 59.9 Ma)
- Pinto Valley/ Carlota (ca. 64.1 to 63.1 Ma)
- Miami-Inspiration (ca. 65.3 to 62.0 Ma)

Christmas (ca. 66.1 to 63.9 Ma)

Ray (ca. 72.1 to 64.4 Ma)

(Hehnke et al., 2012; Seedorff et al., 2019)

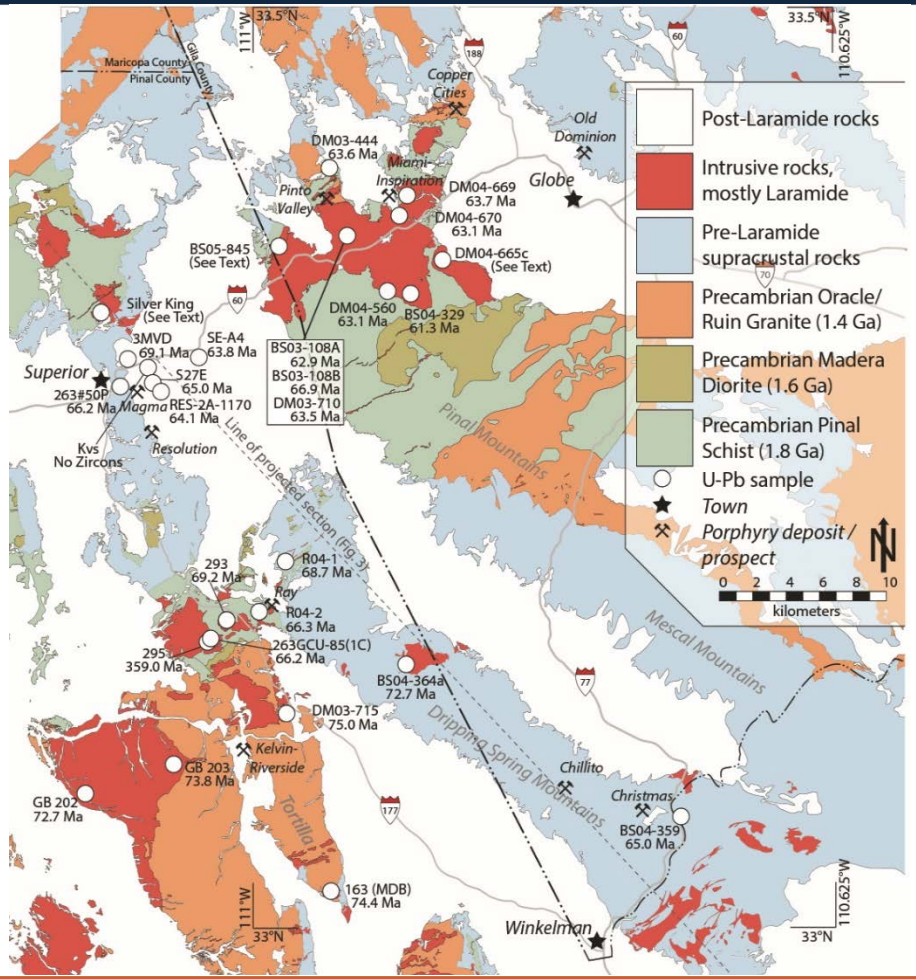


Figure 3. Seedorff et al. (2019)

Samples

Superior District – Silver King

- 19CH-AZ1A (equigranular quartz diorite stock)
- 19CH-AZ1B/D (equigranular monzonite dyke)
- 19CH-AZ1*A (grauss)
- 19CH-AZ2/FZ (fluvial-sand)

Globe-Miami District

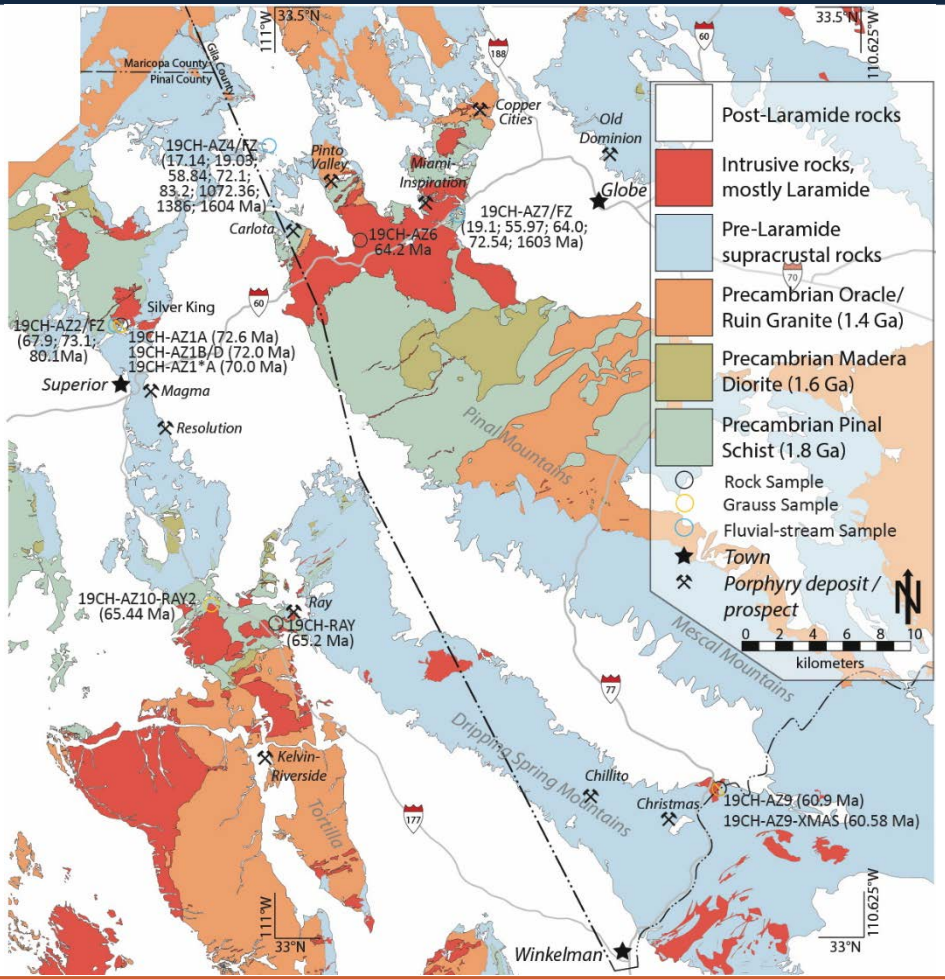
- 19CH-AZ6 (porphyritic granodiorite)
- 19CH-AZ4/FZ (fluvial-sand)
- 19CH-AZ7/FZ (fluvial-sand)

Christmas

- 19CH-AZ9 (porphyritic monzodiorite)
- 19CH-AZ9-XMAS (grauss)

Ray

- 19CH-RAY (porphyritic granite)
- 19CH-AZ10-RAY2 (grauss)



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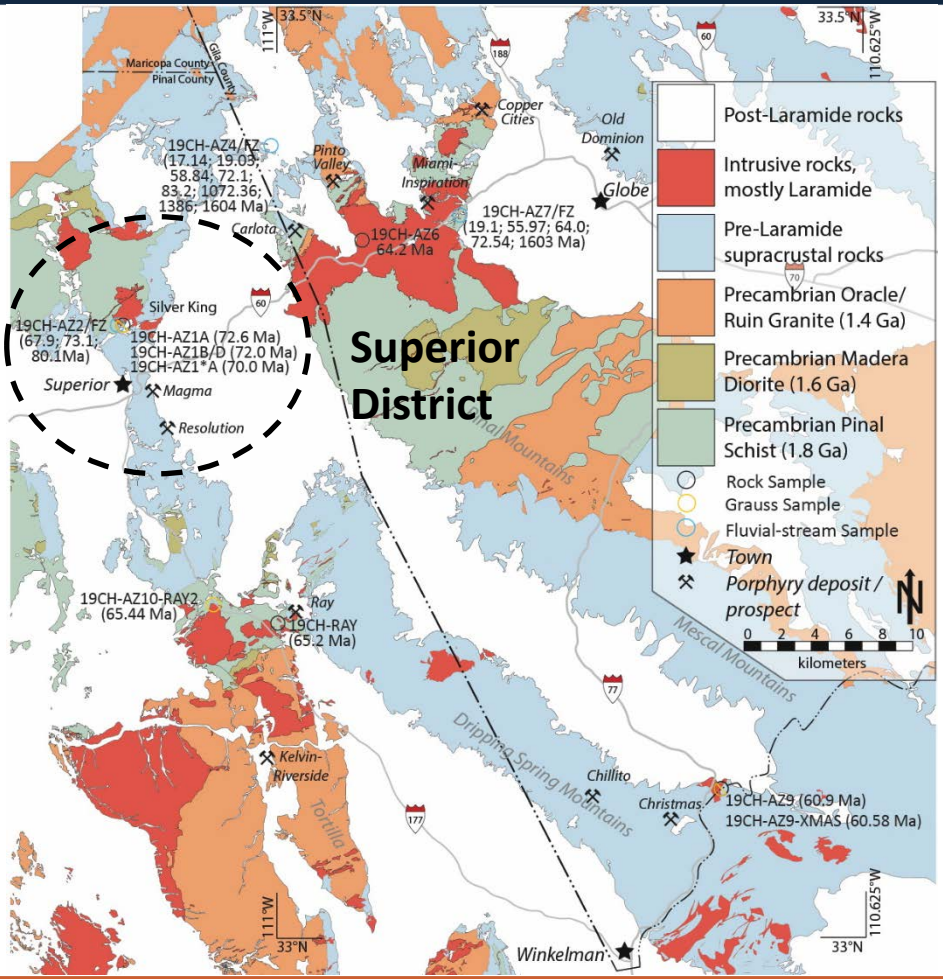

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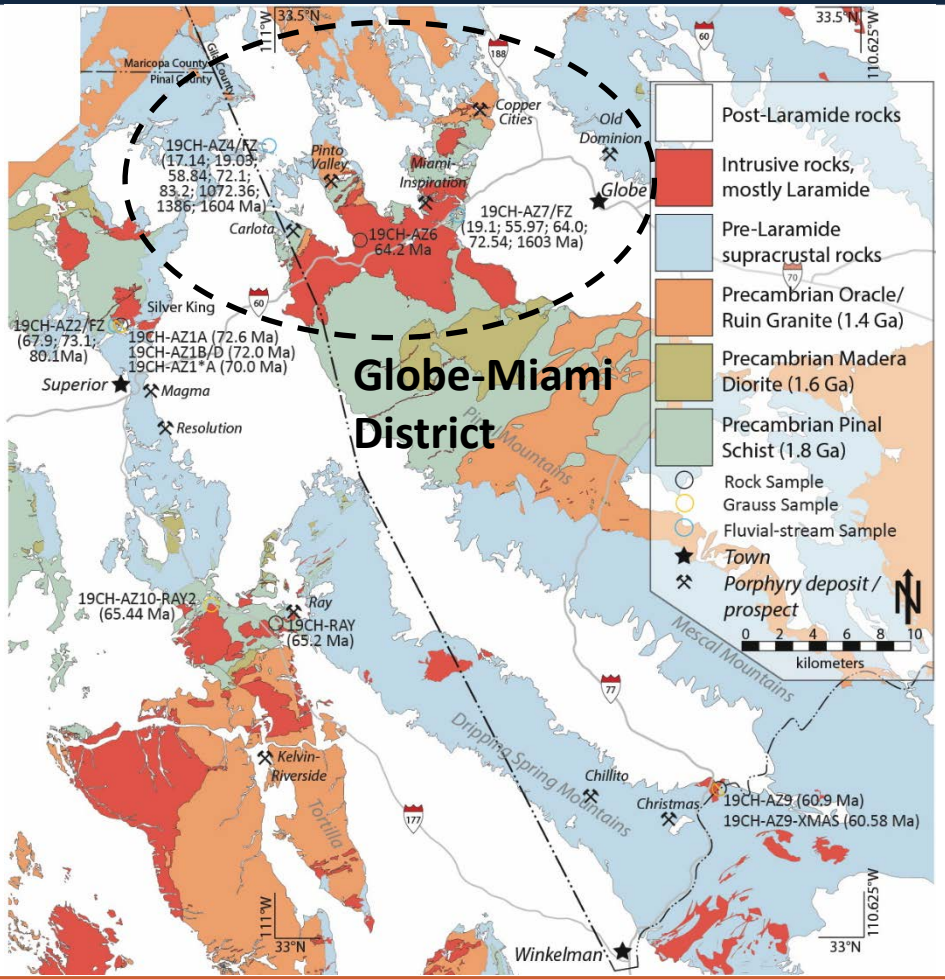

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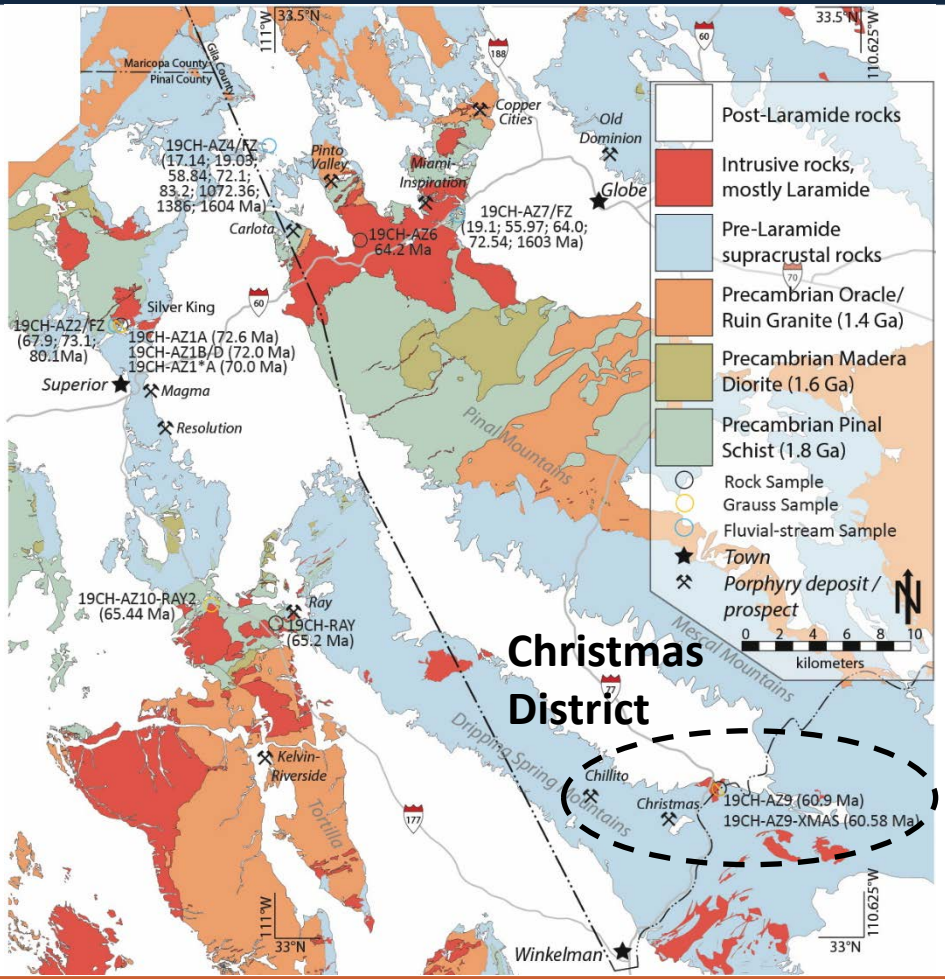

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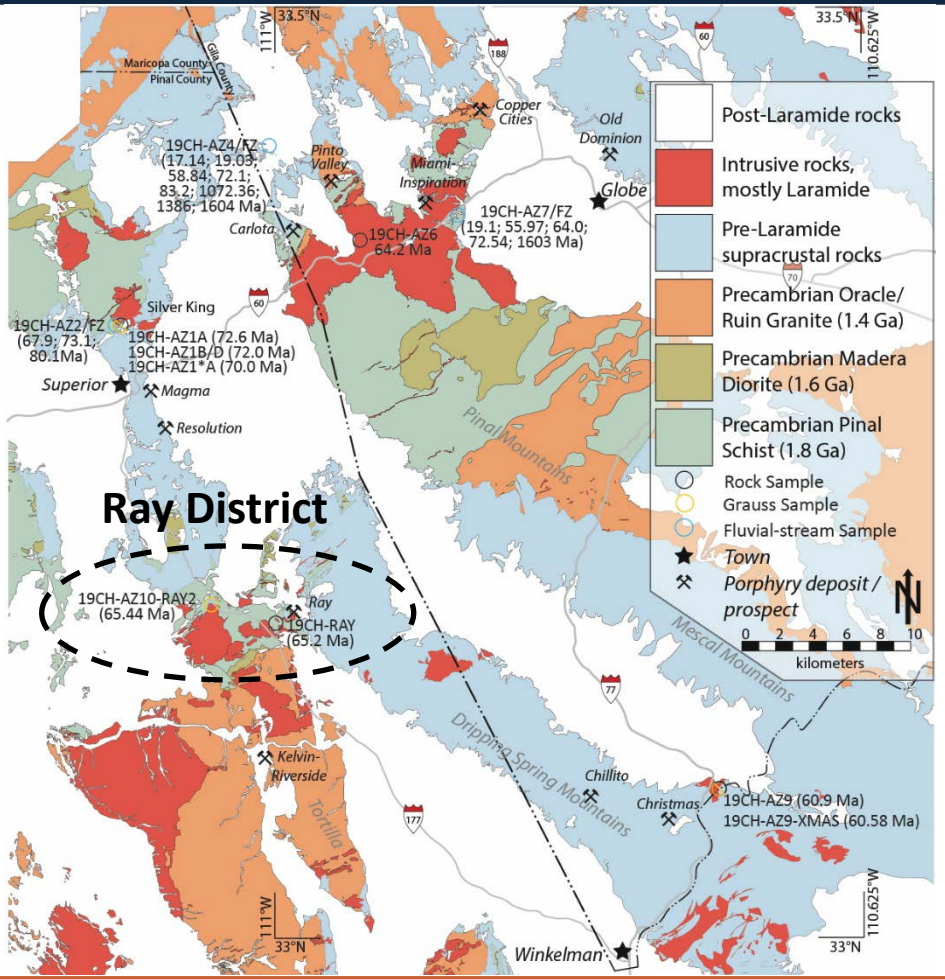


Geology after Seedorff et al. (2019)

Geochronology – Superior District

Silver King stock

Quartz diorite stock **72.6± 2.9 Ma**

- 72.6 ± 2.9 Ma autocrysts (25/25)

Monzonite dike **72.0± 2.3 Ma**

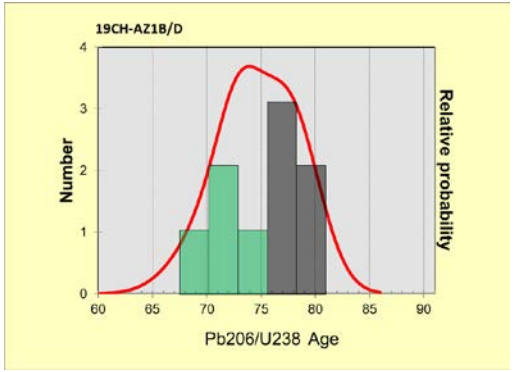
- 72.0± 2.3 Ma autocrysts (4/15)
- 77.3± 2.3 Ma antecrysts (5/15)
- 1407± 290 Ma xenocrysts (6/15)

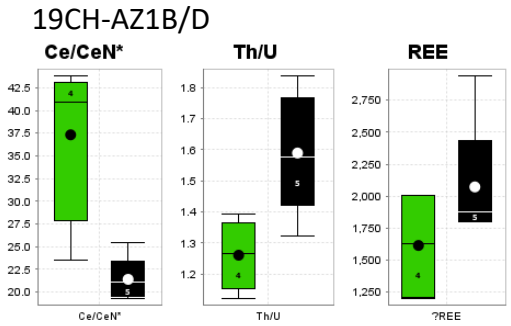
Silver King Grauss **70.3± 1.8 Ma**

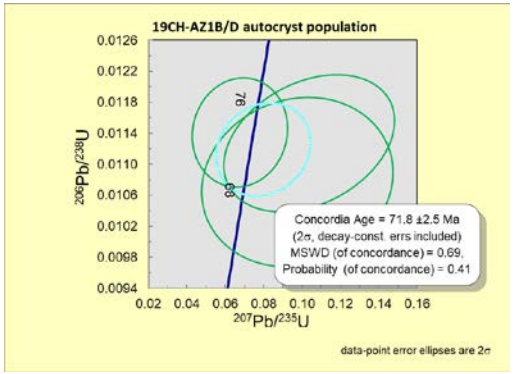
- 65.72± 5.49 Ma (1/9)
- 70.3± 1.8 Ma (7/9)
- 77.77± 4.47 Ma (1/9)

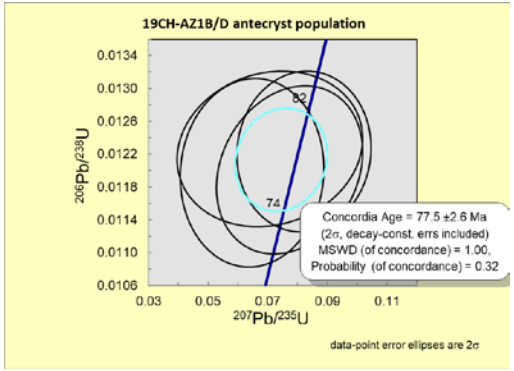
Fluvial Sand **81.42 to 65.84 Ma**

- Laramide 81.42 to 65.84 Ma (57/57)









Geochronology – Globe-Miami District (Schultze pluton)

Schultze pluton

Porphyritic granodiorite **64.2± 3.1 Ma**

- 64.2± 3.1 Ma autocrysts (2/16)
- 1579± 90 Ma xenocrysts (14/16)

NW Pinto Valley

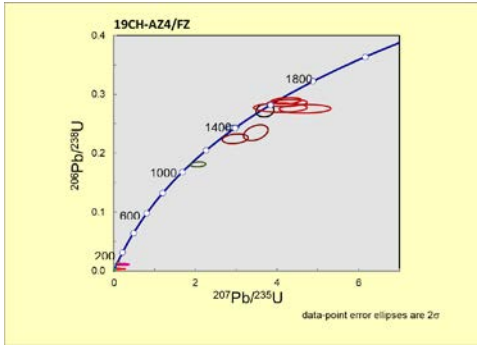
Fluvial sand **16.34 to 1604 Ma**

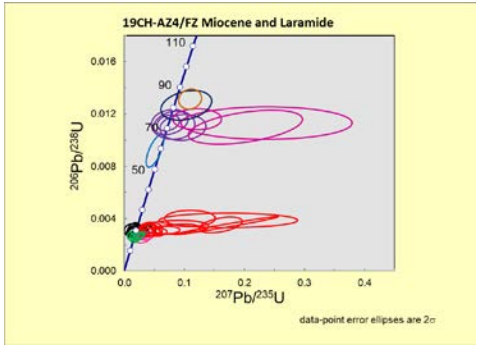
- Early Miocene 20.30 to 16.34 (34/53)
- Laramide 81.0 to 58.84 Ma (10/53)
- Proterozoic 1072, 1386, and 1604 Ma (9/53)

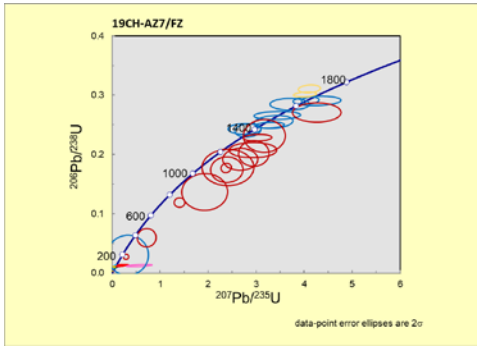
SE Miami-Inspiration

Fluvial sand **18.42 to 1603 Ma**

- Early Miocene 21.84 to 18.42 (2/56)
- Laramide 78.20 to 55.97 (25/56)
- Proterozoic 1603± 69 Ma (9/56)







Geochronology – Christmas

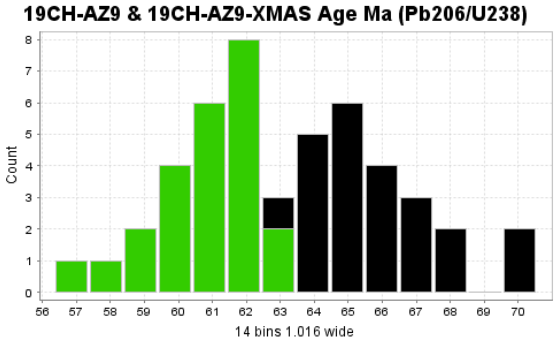
Christmas stock

Porphyritic monzodiorite **60.9± 1.3 Ma**

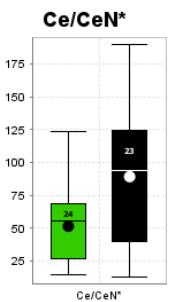
- 60.9± 1.3 Ma autocrysts (11/30)
- 65.7± 1.2 Ma antecrysts (16/30)
- 1367± 52 Ma xenocrysts (3/30)

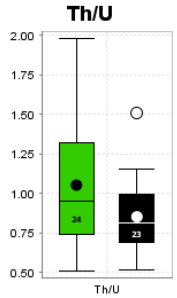
Grauss **60.58± 0.94 Ma**

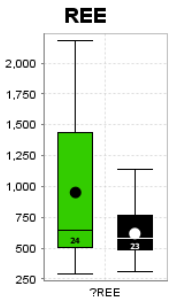
- 60.58± 0.94 Ma autocrysts (14/28)
- 65.1± 1.3 Ma antecrysts (10/28)
- 1427± 210 Ma xenocrysts (4/28)

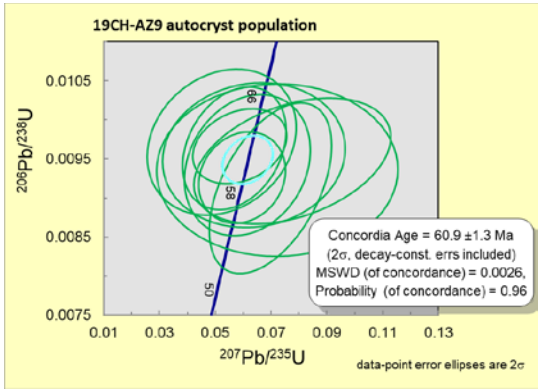


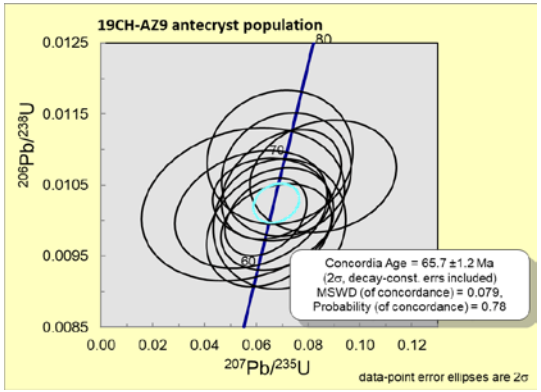
19CH-AZ9 & 19CH-AZ9-XMAS











Geochronology – Ray

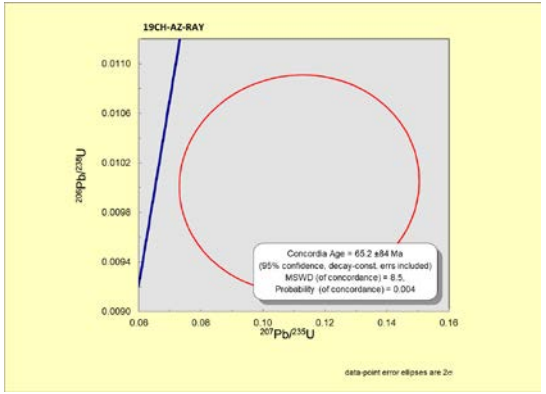
Granite Mountain pluton

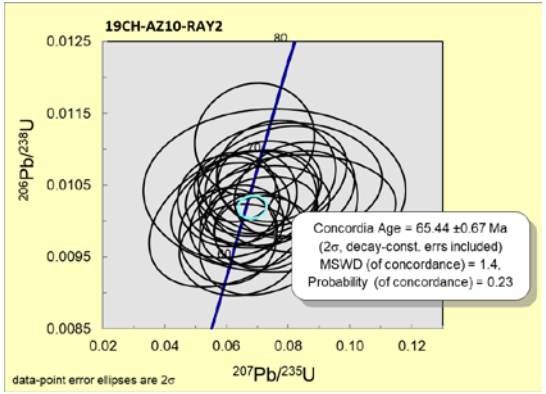
Porphyritic granite **64.34± 4.57 Ma**

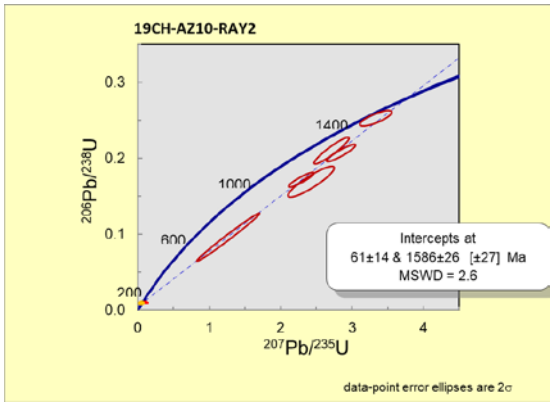
- 1 moderately discordant grain

Grauss **65.44± 0.62 Ma**

- 65.44± 0.62 Ma autocrysts (30/36)
- 1586± 26 Ma xenocrysts (6/36)



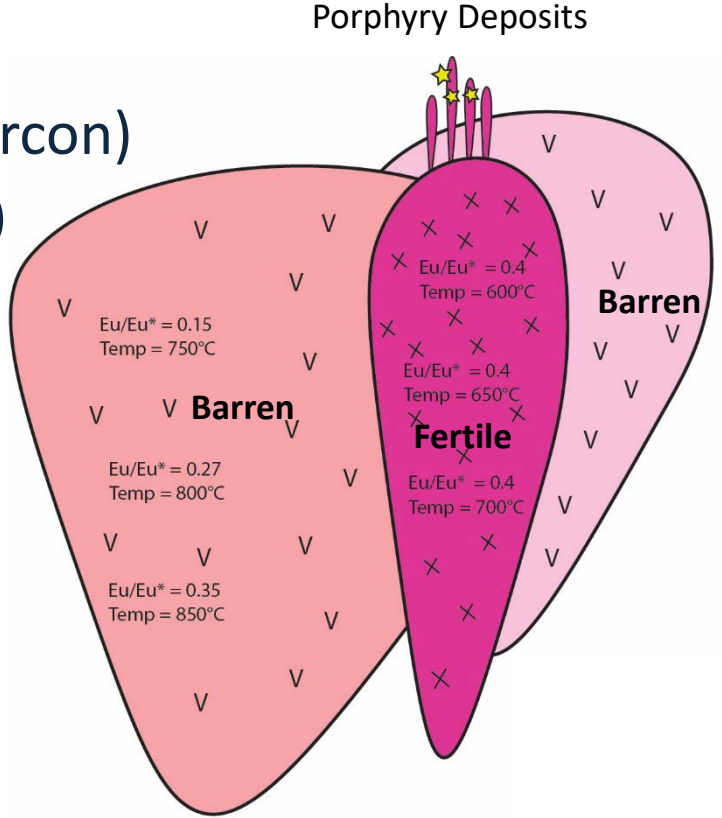




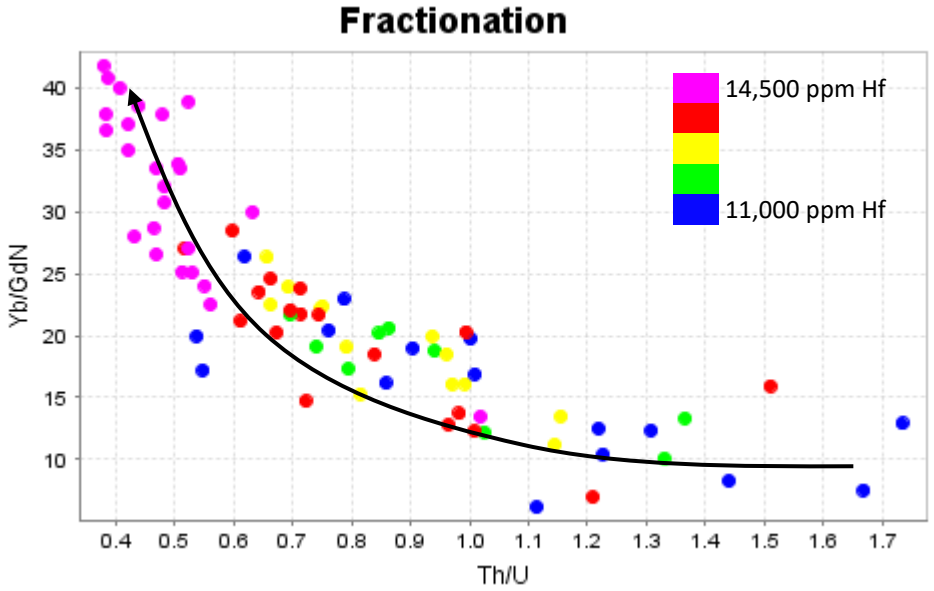
Porphyry Magma Fertility

Key Magmatic Parameters (Proxies in Zircon)

1) **Oxidation State** (Eu/Eu*, Ce/Ce*, & ΔFMQ)
2) **Temperature** (Ti-in-zircon-thermometer)
3) **Water Content** (Eu/Eu*)
4) Metal Content
5) Chlorine Content
6) Sulphur Content



Trace Elements in Zircon (TEZ)



Crystal Fractionation

- ↓ Th/U
- ↑ Yb/Gd_N
- ↑ Hf

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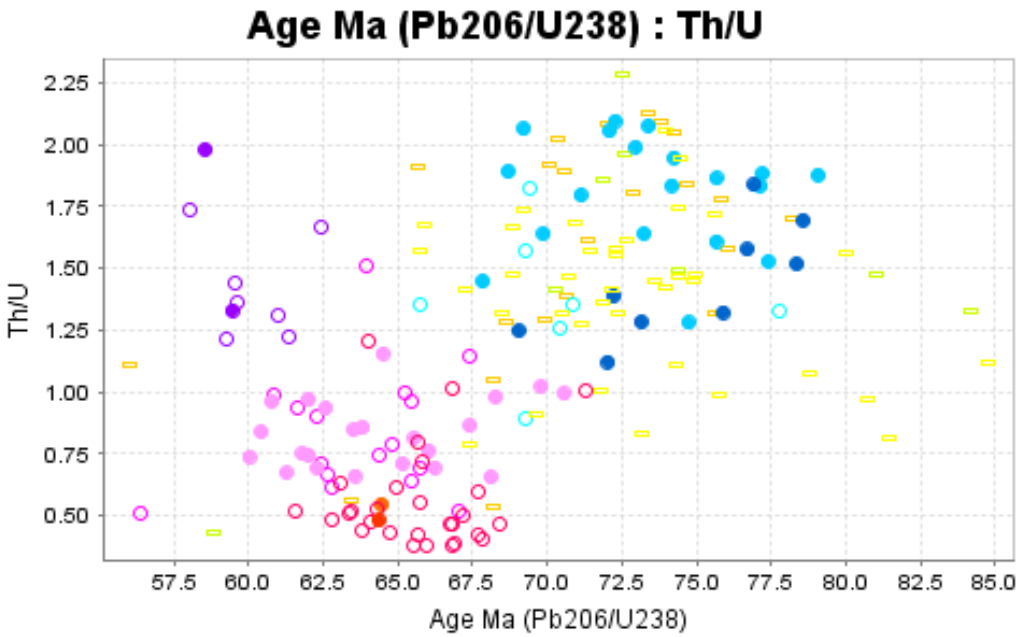

Christmas
- Monzodiorite (Grauss)
- Monzodiorite
- Monzodiorite, primative autocrysts
- Monzodiorite (Grauss), primative autocrysts

Ray
- Granite (Grauss)
- Granite

Globe-Miami
- Granodiorite
- Fluvial-sand, Pinto Valley
- Fluvial-sand, Miami-Inspiration

Silver King
- Fluvial-sand, Silver King
- Quartz diorite (Grauss)
- Quartz diorite
- Monzonite

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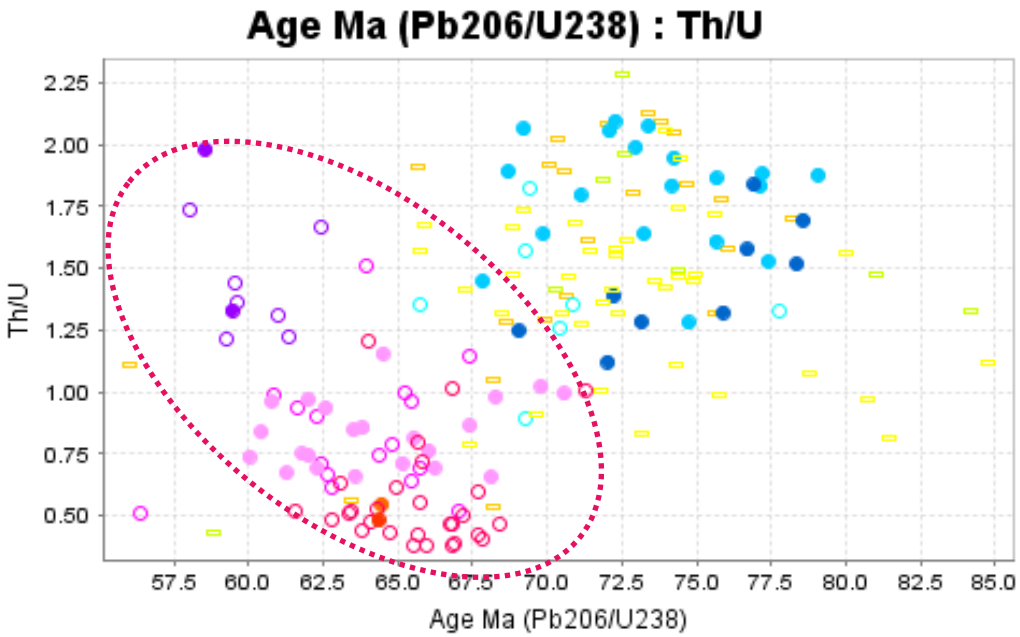

Fertile young population

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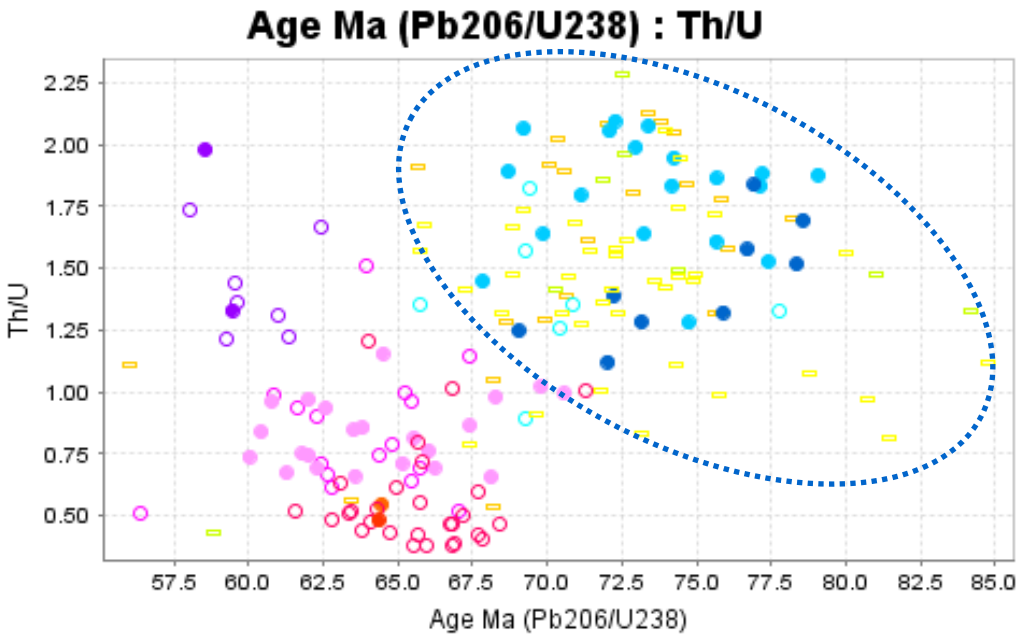

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- Granodiorite

Baren old population
- Fluvial-sand, Pinto Valley
- Fluvial-sand, Miami-Inspiration

Silver King
- Fluvial-sand, Silver King
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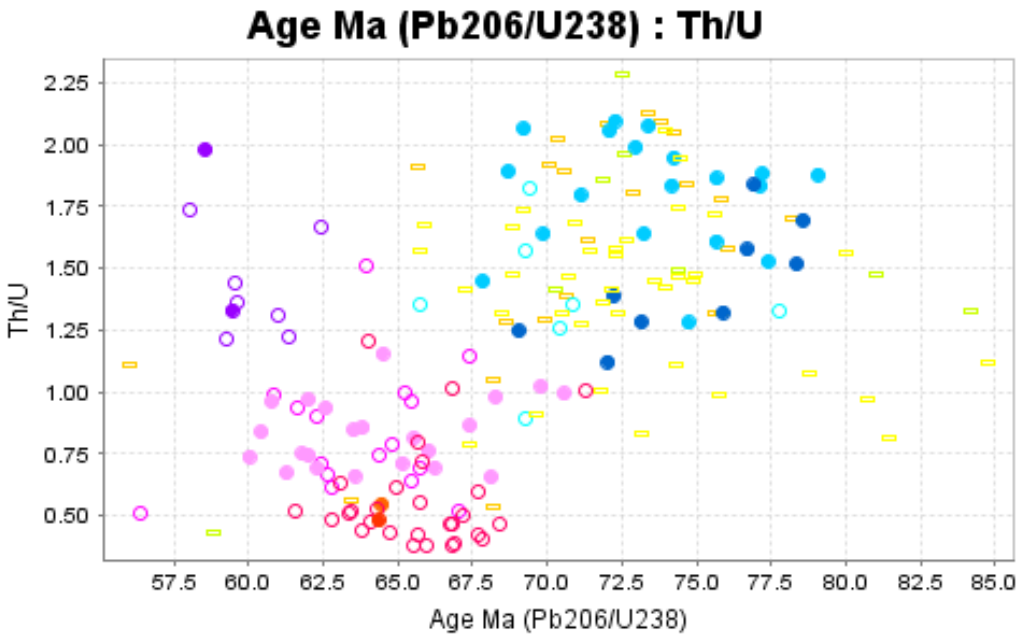

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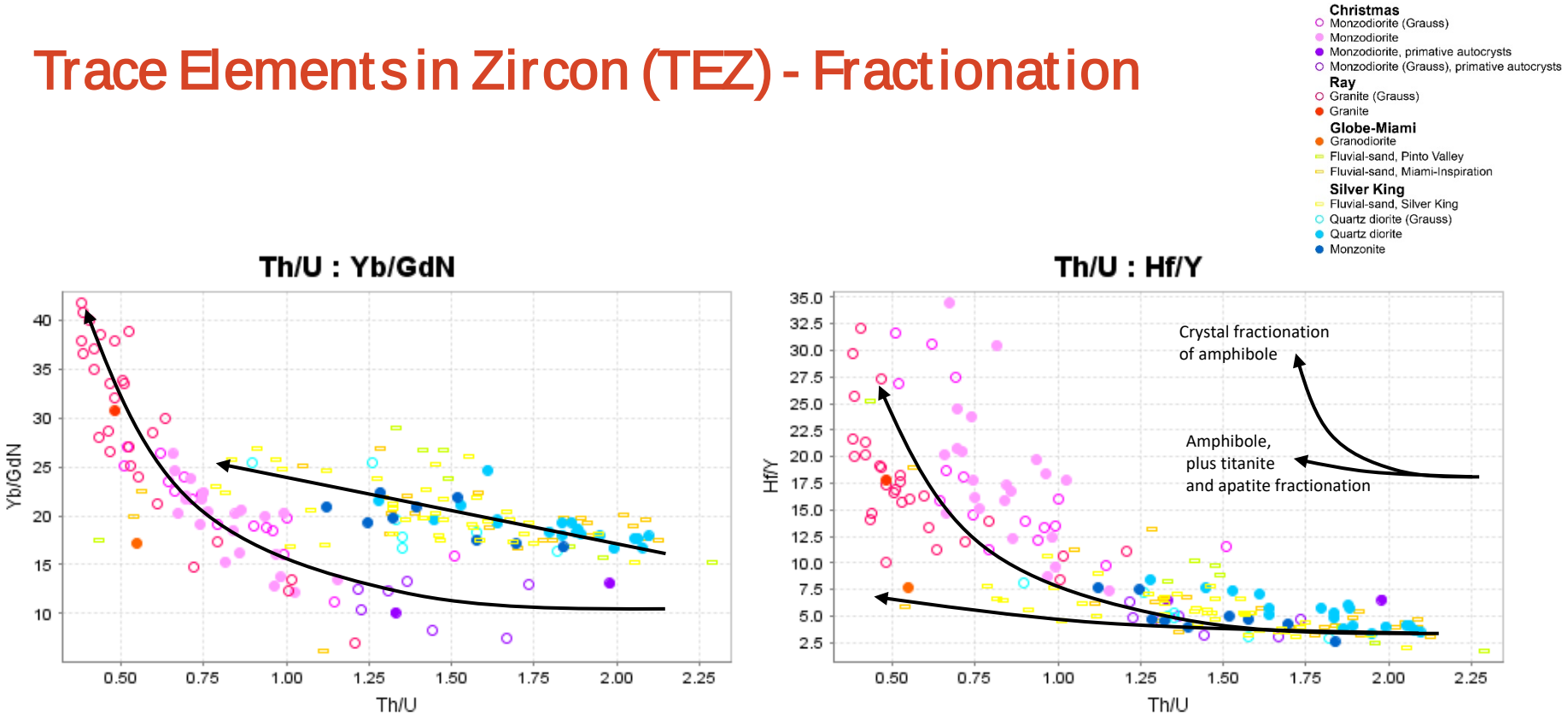
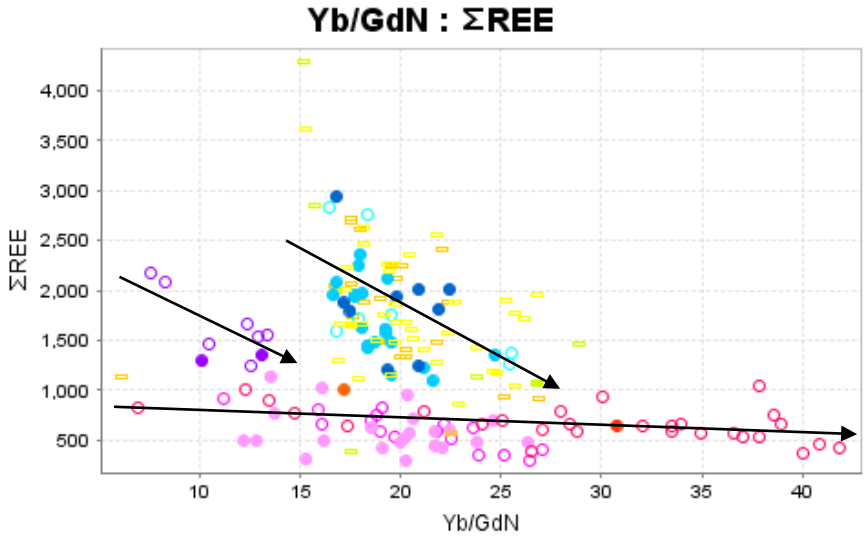
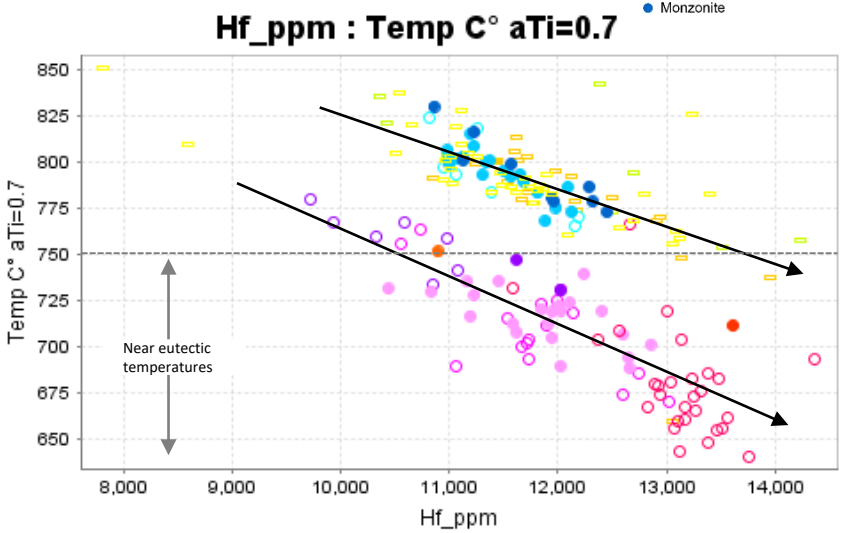
Trace Elements in Zircon (TEZ) - Fractionation



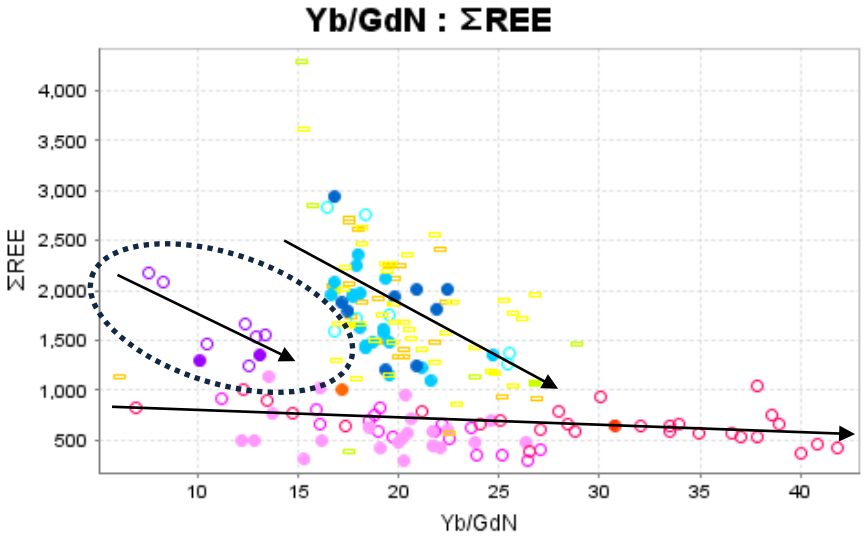
Fractionation trends after Lee et al., 2020

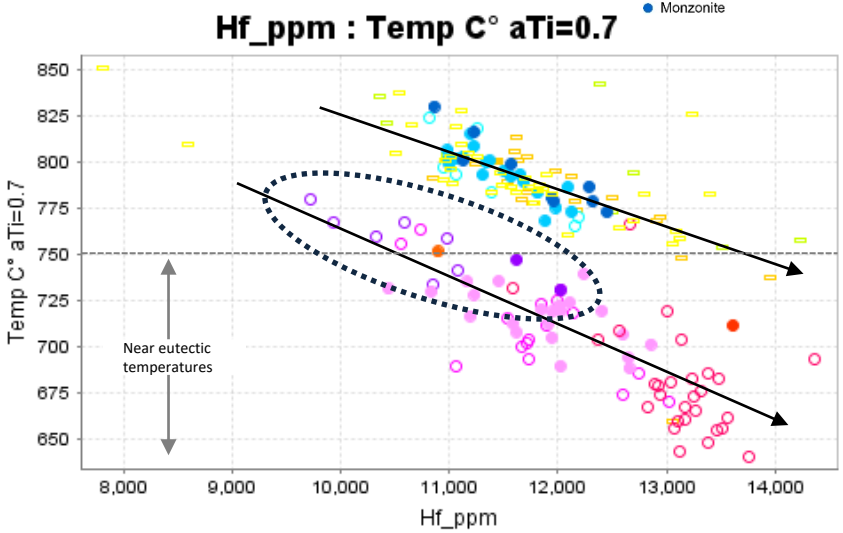
Trace Elements in Zircon (TEZ)





Trace Elements in Zircon (TEZ) – Magma Recharge





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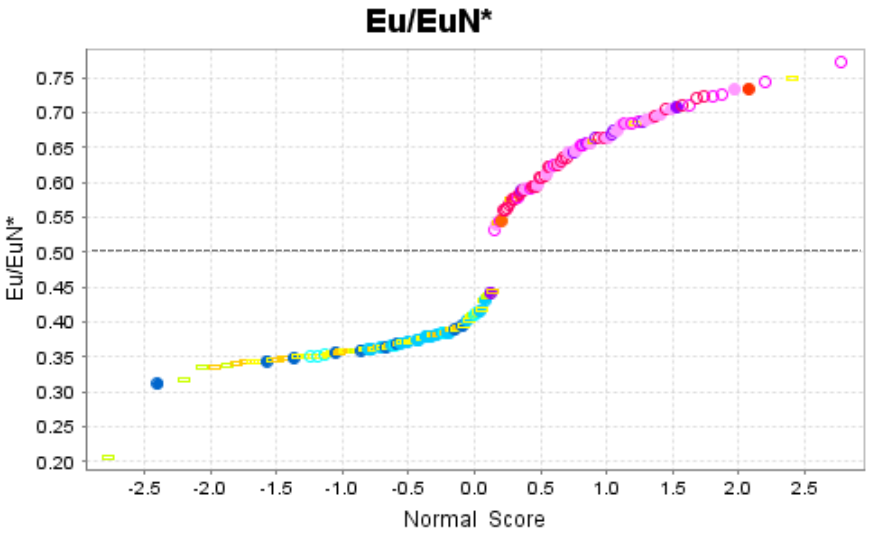
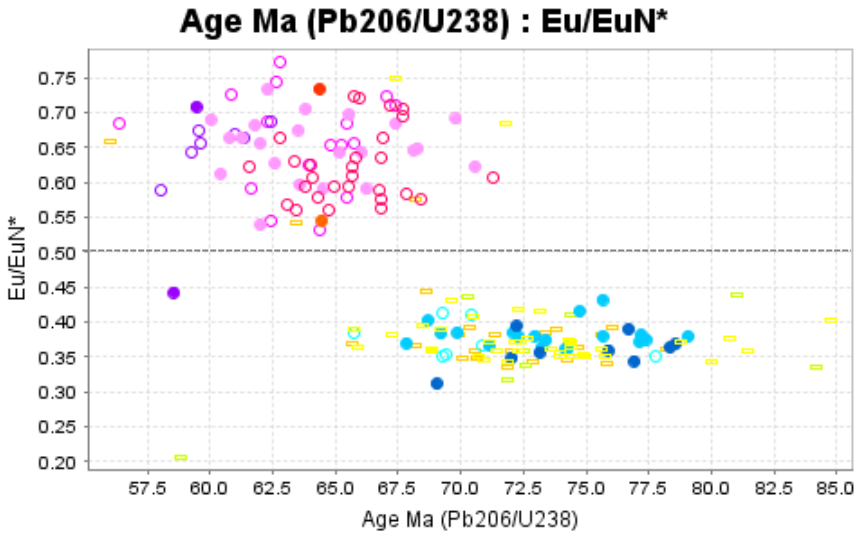
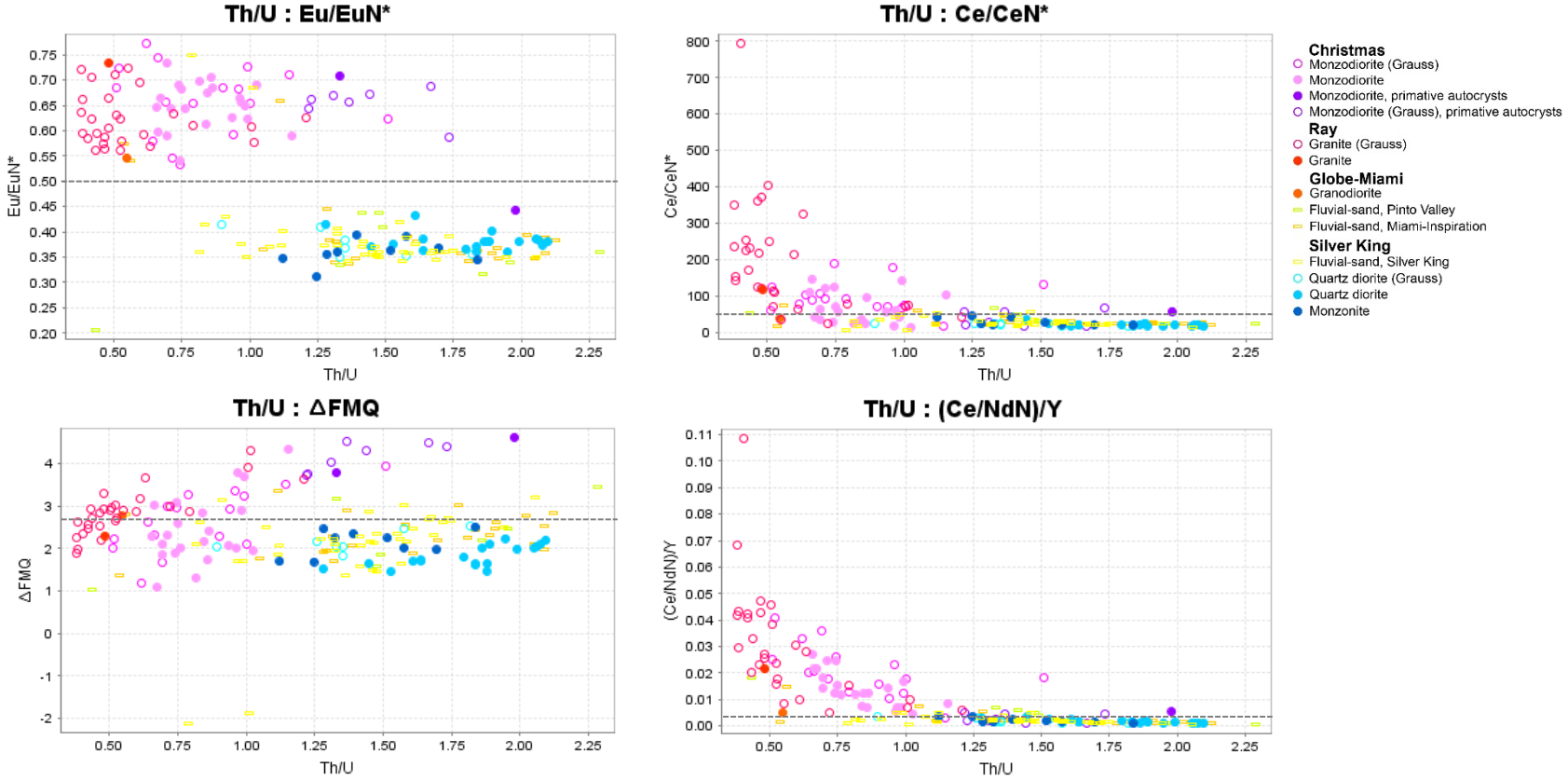
Globe-Miami
- Granodiorite
- Fluvial-sand, Pinto Valley
- Fluvial-sand, Miami-Inspiration

Silver King
- Fluvial-sand, Silver King
- Quartz diorite (Grauss)
- Quartz diorite
- Monzonite

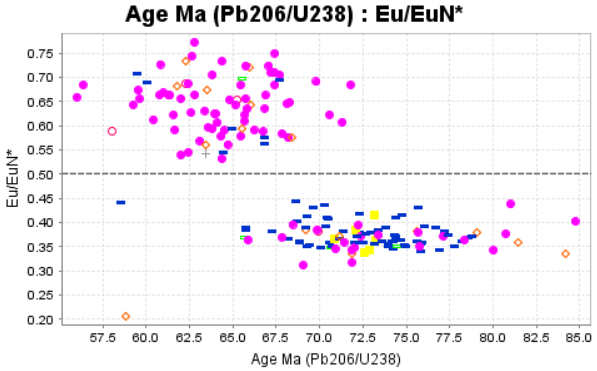


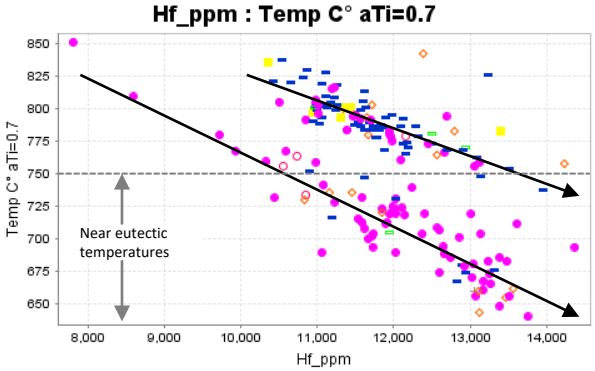


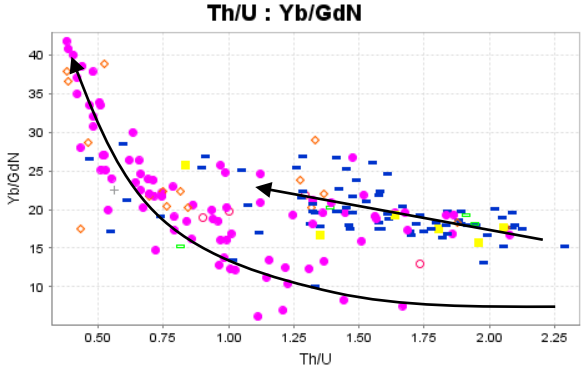
Trace Elements in Zircon (TEZ) – Porphyry Fertility Indicators



Trace Elements in Zircon (TEZ) – Internal Zoning

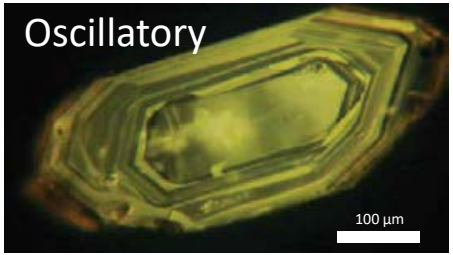


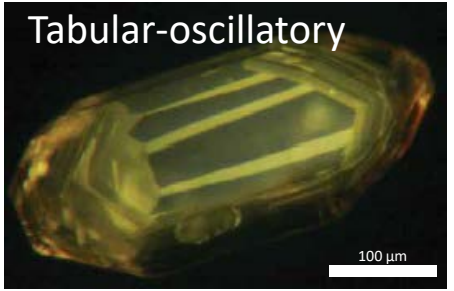


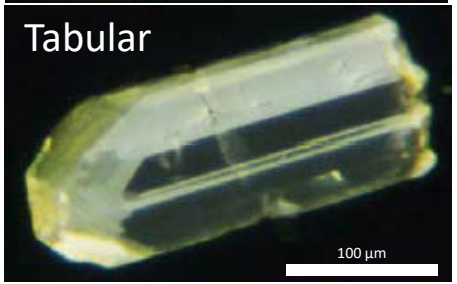


Internal texture

- oscillatory
- oscillatory-irregular
- irregular
- tabular
- tabular-irregular
- tabular-oscillatory







CL images from Bouzari et al. (2020)

Summary

- **Laramide plutonism** in the district ranged from **ca. 81 to 56 Ma**.
- **Magma chemistry** continuously **evolved** throughout plutonism.
- **Fractionation** became **amphibole dominated** ca. ~69 Ma.
- **Younger** intrusions were **oxidized, hydrated** and crystalized at **lower temperatures**.
- **Late magmatism** may have included **mafic magma recharge.**
- Zircon **zoning textures** can identify key **porphyry-fertility** and **magmatic fractionation** characteristics.

Thanks for listening

SEG Canada Foundation

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